# Ecological Flows Science Advisory Board (EFSAB)
# Meeting Summary
# March 15, 2011

**Archdale Building Hearing Room    Raleigh NC**

**__x__APPROVED (For Distribution)**

## Attendance

***Ecological Flows Science Advisory Board***

**Members**

Donnie Brewer, EMC
Mark Cantrell, US Fish and Wildlife Service
Bob Christian, NC Marine Fisheries Commission
John Crutchfield, Progress Energy
Tom Cuffney, U.S. Geological Survey
Linda Diebolt, Local Governments
Chris Goudreau, NC Wildlife Resources Commission
Jeff Hinshaw, NC Cooperative Extension
Jim Mead, NC Division of Water Resources
Sam Pearsall, Environmental Defense
Judy Ratcliffe, NC Natural Heritage Program
Jaime Robinson, NCAWWA-WEA
Fritz Rhode, National Marine Fisheries Service
Jay Sauber, NC Division of Water Quality
Bill Swartley, NC Forestry Association

**Alternates**

Cat Burns, The Nature Conservancy (via web)
Peter Caldwell, USDA Forest Service
Vernon Cox, NCDA&CS
Steven Reed, Division of Water Resources
Arlene Roman, Local Government (via web)
Vann Stancil, Wildlife Resources Commission

***Division of Water Resources Staff***

Tom Fransen (via web)
Don Rayno
Sarah Young

**Facilitation Team**

Mary Lou Addor, Natural Resources Leadership Institute (NRLI)
Patrick Beggs, Watershed Education for Communities and Officials (WECO)
Christy Perrin, Watershed Education for Communities and Officials (WECO)
Nancy Sharpless, Natural Resources Leadership Institute (NRLI)

**Guests:**

Gene Addesso, BRBA
Jenny Atkins, NCDWQ
Connie Brower, NCDWQ
Mary Davis, TNC/SARP
David Elliot (via web)
Lisa Gordon (via web)
Jeri Gray, WRRI (via web)
Kyle Hall (via web)
Lars Hanson
Paul Leonard, (via web)
Brian McCrodden, Hydrologics
Dan McLawhorn, Raleigh, Attorney's Office
Joe Pfeiffer (via web)
Haywood Phthisic, LNBA/NRCA
Carrie Ruhlman (via web)
Nikki Schimizzi, NCDWQ
Ty Ziegler, HDR/DTA (presenter)

## The purpose of the Ecological Flows Science Advisory Board:

The Ecological Flows Science Advisory Board will advise NC Department Environment and Natural Resources (NCDENR) on an approach to characterize the aquatic ecology of different river basins and methods to determine the flows needed to maintain ecological integrity.

**Presentations, reports, and background information about the E-Flows SAB are available at:**
[www.ncwater.org/sab](http://www.ncwater.org/sab)

## March 15, 2011: Decisions Made/Actions to be Taken

A. The January 18, 2011 Meeting Summary was approved and is posted on the E-Flows SAB website.
B. The EFSAB will move forward using the existing classification system strategy as a starting point, with the opportunity to add or modify additional classifications as they gain information.
C. Three changes were made to the charter. See **Section VII: Review of Charter**.
D. With the changes to the charter listed in Section VI, the Charter was approved, March 15, 2011.
E. Alert Jim Mead about any headwater studies and available data (USFS, NCSU, …) that can meet the 15-20 year criteria established by EFS.

## March 15 2011 Meeting Agenda

I. Executive Summary
II. Welcome
III. Agenda Review and Introductions
IV. Review of January 18, 2011 Meeting Summary
V. Review and Discussion of Stream and River Classification Presentation at January meeting
VI. Instream Flow Habitat Studies Presentation
VII. Review of Charter
VIII. Revisit What Members Need from November Meeting
IX. Develop Agenda for May Meeting

## I. Executive Summary (Executive Summary added in 2013 by facilitation team)

### Debrief of January 18, 2011 Stream and River Classification Presentation

In January, there was limited time to debrief the Stream and River Classification presentation. A recap of the presentation included:

- NC *Streamflow* is the hydrologic classification model used in North Carolina.
- Analysis using this model divided the streams and rivers in NC into 7 classes of streams [and were subsequently subdivided, establishing 11 categories].
- Why classify? We are dividing the streams into classes of consistent types that are significantly different from each other, and thereby might lend themselves to developing a different approach to determining ecological flow for each class.
- Comparing results from actual USGS gage data to simulated data using the river basin model for the Neuse River basin, lessons learned were:
    - Include nodes at all gage sites so can continue to test.

- Be wary of the first year of data because often the models need a first year run-through to get things stabilized; you can get quirky results if you use the first year of simulated data.
- The longer the period of record, the better; one of the advantages of the model is that it includes 70 years of daily stream flows to run through the classification software.

At the March meeting, a tentative agreement was supported by the EFSAB to utilize the NC *Streamflow* classification in future discussions as a potential way to subdivide streams in terms of how generating approaches to characterize ecological flows.

Two reference papers related to classification and instream flow habitat studies were distributed: the R.A. McManamay et al. (2011) and J.G. Kennen et al. (2009). The Kennen paper is available at http://www.ncwater.org/sab and the McManamay paper was sent to the EFSAB. The literature is offered because even though the hydrology and geology of Missouri and North Carolina are different, the framework of the Missouri study [Kennen et al. 2009] was similar to NC efforts (statistical efforts were different). The McManamay study was a regional approach that looked at selection of gages in eight southeastern states. The study pointed out that it is not possible to do site specific studies for every stream and river; that typically southeastern states have used statewide characterization of ecological flow (one size fits all), but they believe that this is inadequate for describing the variety of flow regimes that support ecological diversity. What NC is trying to do is split the difference into something distinguishes between significantly different types of streams, for determining ecological flows.

**Questions, Comments, and Concerns Raised**

A list of questions was sent to the EFS to understand the statistical methods used in classification method and to document the approach for future reference.

Other questions were raised: about period of record, why coastal streams only had one classification, the possibility of splitting coastal streams into tidal and non-tidal segments or where there are higher areas of salinity, surface water withdrawals are not likely to be that much of an issue, how to factor in smaller streams, given biological data, is it primarily for the smaller streams or for the larger streams, or are we basically working from the middle outward, about using other flow data from Coweeta, Stormwater

Comments raised included:

- The importance of considering the base line of the coastal stream as brackish water may be withdrawn for future water supply and significant alteration of the water in the upstream segment in a different class could violate the base line of a coastal stream.
- Value of the Susquehanna River report (Nature Conservancy, 2010) that used a combination approach: (1) hydrologic classification, and (2) they pulled in other sampling data of organism density.

- Using USGS data for the EFS classification vs other kinds of existing flow data.
- "What are the upper limits of certain classification types?" IN the EFS Classification system, the drainage area goes all the way down to less than two square miles, which is pretty small. For planning purposes, there is de facto upstream limit given the node location.
- Start with the hydrologic model and then add the ecological, with the understanding that classifications may be added. This is a starting point; the current model does not include factors like tidal influence, salinity wedge, etc.

**Proposed Actions or Identified Decisions to be made:**

The EFSAB determined that they would like to move forward using the existing EFS classification system strategy as a starting point, with the opportunity to add or modify additional classifications as they gain information.

Alert Jim Mead about any headwater studies and available data (USFS, NCSU, …) that can meet the 15-20 year criteria established by EFS.

**Instream Flow Incremental Methodology (IFIM) Presentation**

Ty Ziegler, P.E. from HDR/DTA who provided a presentation on **Instream Flow Incremental Methodology to the Ecological Flows Science Advisory Board at the March 15 meeting.** The presentation introduced a methodology to quantify how flow can change and affect aquatic habitat. Ty began his presentation by describing instream flow and Instream Flow Incremental Methodology (IFIM). He explained that IFIM is a way to relate: ***changes in river flow to changes in the amount of aquatic habitat on an incremental basis,*** by looking at very fine increases or decreases in flow and the resulting effect on aquatic habitat. This relationship is expressed between River Stage (ft) and Discharge (cubic ft/sec). Usually as the amount of discharge increases, the river stage increases. With IFIM, the objective is to come up with the relationship between Habitat and Discharge, with discharge along the x-axis and weighted usable area (habitat in a unit of measure) along the y-axis. The difference in the relationships is that with Stage vs. Discharge, as discharge increases, the river stage increases; in Habitat vs. Discharge, as discharge increases, the habitat data can be all over the place depending on the type of aquatic species and given different habitat needs of different life stages of the species. For IFIM studies, it is a milestone step to come up with this relationship.

What's important for defining aquatic habitat for IFIM? While many factors are important in defining aquatic habitat, including food availability, predators, water quality, and water temperature, **four physical parameters are considered in IFIM: depth, velocity, substrate and cover (hiding spots).** These parameters will affect different species differently and different life stages of a single species differently. There are (10) steps of the IFIM process:

1. Field Reconnaissance & Habitat Mapping
2. Study Design
3. Habitat Weighting
4. Transect Selection & Setup

5. Field (Flow) Measurements
6. PHABSIM Modeling
7. Time Series Analysis
8. Habitat Results
9. Habitat Based Flow Determination
10. Study Report

**Questions, Comments, and Concerns Raised**

- When you are modeling on a big scale for planning purposes and over a larger time scale presumably as well, how do you translate your previous scale to a bigger scale knowing your river morphology is going to change?
- These models seem to be good at predicting physical habitat change and availability. Do you have enough experience with these types of models to understand the dynamics of interaction between species?
- What really happens when change in habitat might favor one species under one set of conditions but also might favor the predator of that species?
- What really happens when change in habitat might favor one species under one set of conditions but also might favor the predator of that species?
- In terms of validation studies, how many validation studies are there where they have gone in, set this up, and tested the stream flow, the effects of the stream flow – 100s? tens? 2?.
- How does temperature factor into these models?
- How do you balance the needs of various species to provide recommend flows?
- How do you use the IFIM process to address/describe the variability of flow?
- Can you use a tool like this to develop operating guidelines for dam or hydro releases?
- Have you tried modeling, thinking of migratory species for example, have you tried using this model type approach to evaluate the effect of variability on species, not just a set habitat of a fixed amount plus or minus but the variations in habitat itself?
- Do you have methods for assessing uncertainty for these different components and getting at the critical issue which is really what's the probability that you're going to wind up falling below some critical level

Comments raised included:

- DENR is interested in looking at the IFIM approach given the number of studies around the state. A focus on the red bars and then using the Oasis type models to run proposed flows may help determine where the green and blue bars go if one does A-Z? This could inform discussions for ecological flows; link aquatic habitat and flows.
- Seldom is anyone putting money into the long-term monitoring.
- Good examples in NC where there may be improvements in flow and aquatic habitat is with hydropower relicensing. Maybe in 5 to 10 years we will have more data specific to North Carolina about the kinds of improvements we are getting.
- The McManamay study references the Tapoco project on the Cheoah in NC. He introduces flows, hypothesize about species, and community benefits. He work is ongoing. He had to look to a broader region to explain some of the differences in the community fish response (the interactions, the predation, the competition, as well as all of the seasonal fluctuations, something you cannot test in the initial year when you do physical modeling).

- IFIM is often associated with dams and releases (an increase in cfs). Unclear how these tools work with withdrawals, when you take flows away at a given time, and you do not have the ability to increase flows to increase habitat availability. In the planning system, where do you see the control coming in with withdrawals? See "run of river withdrawals"

**Proposed Actions or Identified Decisions to be made:**

In the collaboration for which species will be included, choices will need to be made about which ecological factors go into the IFIM model.

## II.Welcome

Jim Mead, Environmental Supervisor with the NC Division of Water Resources (DWR), welcomed everyone to the third meeting of the Ecological Flows Science Advisory Board (EFSAB). He announced that NCDWR would distribute a reference book, I*nstream Flows for Riverine Resource Stewardship, 2nd Ed.,* an Instream Flow Council publication.

## III. Agenda Review and introductions

Mary Lou Addor, facilitator, introduced herself and invited everyone to introduce themselves including their affiliation. She then reviewed the agenda.

## IV. Review of January 18, 2011 Meeting Summary

Nancy Sharpless, facilitator, asked if anyone had additional revisions to the January 18, 2011 Meeting Summary, besides the editorial revisions that were received and included. No new revisions were suggested, and the EFSAB approved the January 18, 2011 Meeting Summary. The Final summary is posted on the EFSAB website at http://www.ncwater.org/sab

## V. Debrief of Stream & River Classification Presentation (January 18,2011 Meeting)

At the January 18, 2011 meeting, the EFSAB had limited time to discuss the Stream and River Classification presentation. Jim Mead provided a short recap of the presentation, highlighting the following points:

- NC Streamflow is the hydrologic classification model used in North Carolina.
- Analysis using this model divided the streams and rivers in NC into 7 classes of streams [which were subsequently subdivided, establishing 11 categories].

- Why classify? We are dividing the streams into classes of consistent types that are significantly different from each other, and thereby might lend themselves to developing a different approach to determining ecological flow for each class.
- Comparing results from actual USGS gage data to simulated data using the river basin model for the Neuse River basin, lessons learned were:
    - Include nodes at all gage sites so can continue to test.
    - Be wary of the first year of data because often the models need a first year run-through to get things stabilized; you can get quirky results if you use the first year of simulated data.
    - The longer the period of record, the better; one of the advantages of the model is that it includes 70 years of daily stream flows to run through the classification software.

Tom Cuffney had raised several good questions regarding the statistics and methods used in developing the classification scheme. Since the January meeting, Tom put together a list of questions and clarifications of how to document the approach for future reference. Those have been forwarded to the consultant who developed the classifications. He has provided an initial response to the questions, and he and Tom will discuss further. The questions are not regarding validity of the analysis, but rather documentation of the approach.

Since the last meeting, DWR sent two papers (R.A. McManamay et al. (2011) and J.G. Kennen et al. (2009)) related to classification and instream flow habitat studies to the EFSAB to read, The Kennen paper is available at http://www.ncwater.org/sab > Documents > March 15. The McManamay paper was sent to the EFSAB. Although the hydrology and geology of Missouri and North Carolina are different, the framework of the Missouri study [Kennen et al. 2009] was similar to what has been done in North Carolina, but the statistical methods were different. The McManamay study was a regional approach where they looked at a selection of gages in eight southeastern states. If you consider state data as a more fine resolution for classification and national efforts as more coarse resolution, McManamay's work was in the middle. The national classification had only three classifications in NC. The Missouri classification used five classifications. In NC, we are in line with what others are doing.

We are looking for at least a tentative agreement at the end of today that NC Streamflow classification is a good way to subdivide streams in terms of how to go about finding ways of determining ecological flows - at least for now, unless we learn better.

As McManamay et al. point out, it is not possible to do site specific studies for every stream and river. Their paper further states that, traditionally, southeastern states have used statewide characterization of ecological flow (one size fits all), but they believe that this is inadequate for describing the variety of flow regimes that support ecological diversity. What NC is trying to do is split the difference into something reasonable, that distinguishes between significantly different types of streams, for determining ecological flows.

Christy Perrin, facilitator, then solicited the EFSAB's initial reactions to the classification approach that had been presented. The following questions, comments and responses were offered:

*Question:* One of my concerns is how the period of record works. I understand that longer is better. My question regards the break in the 1980s that required shortening the period of record. There were changes in NC in the early 1900s that would have resulted in changes from the natural state as well. At what point is it appropriate to conglomerate those and at what point is it appropriate to break?

*Response:* The whole period of record question is a difficult one. One approach would be to find one range of years that all gages had in common, with more than 18 years of record; however, there are so few with a common period of record that this would greatly reduce the data available for the analysis. We decided to use the record available for the USGS gages unless there had been some major manmade flow-altering event, such as addition of a dam. We tested the classification software using OASIS, which produces a common 70-year period of record for all 31 gages in the Neuse River Basin. We compared the results using this 70–year period of record with using actual USGS data. We got a good match on the classifications, except for nine of the 31, for which we were able to determine the reasons (such as problems with using the first year of simulated data).

*Comment:* I guess my concern was where the first 20 years were used, then having it fall out, I did not fully understand whether that was a better result or whether we needed to be concerned with whether they would all end up being classified.

*Response:* I think there are two points there: (1) Using OASIS, for all rivers where we do not have gages (which is most of them), we will have the simulated 70 year record; I think that will put us on consistent footing; and (2) using these disjunctive periods in the gaging record, is that a flaw? It is not ideal, but I think the tests we did by comparing the Neuse basin gage data with the Neuse basin simulation data took care of those questions, and as we complete other basin models we will be able to do the same thing, as a second check on this issue. When we were struggling with what gages to use, finding pristine gages was challenging because there are changes of volume of wastewater, for example, and they occur incrementally over time. The gages pick up those changes over time. The OASIS model teases all of that out and creates a record as if those changes did not occur. You can then add those back in later when modeling.

*Question:* I am most interested in the coastal streams. Unfortunately they tend not to be gauged. Why is there only one classification for coastal streams? We have variation in tides and salinity (not accounted for in the modeling), which are very important to the ecology. Are we dealing only with gaged streams, or are we dealing with streams that can't be gaged because we can't gage tidal zones?

*Response:* You are right. There are not many gaged coastal streams. We are going to be dealing with ungauged streams to the limits of the OASIS models, which, again, have adopted a downstream limit at which it is no longer your classic flowing water ecology. Each OASIS model's downstream limit is where tidal influence takes over. Having only one coastal classification may be because of scarcity of gage data. McManamay's study also came up with only one coastal classification for the multi-state region at which they looked.

*Comment:* But if you look at where the dots are [indicating gages], they are all up in the upper coastal plain, not the lower coastal plain. He also appears to be limited by gaging capabilities.

*Question:* We split a few of our classifications because they had significant differences; specifically, we split two of them into temperature classes. Why not split coastal streams into tidally influenced segments and non-tidal segments, and develop ecological guidelines differently for them? We could split them at the point where they become tidally influenced.

*Response:* We don't have any of the tidally influenced ones in the data set that produced the classification system.

*Comment:* Understood, but now we take on the challenge of establishing ecological baselines for each of NC's important classes of rivers and streams. It seems like tidally influenced coastal streams certainly qualify as one such. Why not divide?

*Response:* We can't do it with the framework we have now. Texas and Florida are working on this in estuarine areas. We may be able to learn from what they are doing.

*Comment:* From what I understand of their work they are working on developing ecological flows for a class; I am suggesting that we have that class.

*Comment:* The current classification system is probably the best we can do with the data at hand. We know that the gaging sites are not randomly determined but were placed for some reason. But we have nothing more we can work with. What is more important is what we can do in the future. We are working with the OASIS model; we will have more information at more sites. What we would want to do is revisit the classification system as more data develops and we develop more models.

*Response:* We are going to have to revisit. At some point we are going to have to begin refining our classification according to a comprehensive set of models for NC.

*Question:* Could you split coastal streams by salinity, as other streams are split based on temperature? Do you have enough data to justify one split versus another? Did we have enough data to justify splitting the streams based on temperature?

*Question:* Does the Division of Water Quality (DWQ) collect data such as salinity in those downstream coastal areas?

*Response:* I think we have a huge database in those coastal rivers, not necessarily out into the sounds, going back to the 1960's. Whether the frequency and duration of that data adequately captures what is needed for ecological flows is another question.

*Response:* The database sounds wonderful. The fact that it doesn't get out into the sounds isn't a problem because we are looking at rivers. I don't know what statistical approach we should use to analyze those data. Remember, we are trying to develop a testable hypothesis, not a conclusion.

*Question:* The legislation that mandated this determination of ecological flows is aimed at assessing from a water supply standpoint. Once you get down to where you have higher salinity, surface water withdrawals are not likely to be that much of an issue because the water is too saline for use, even though at some point it might be necessary to have ecological flows for planning purposes. The Wildlife Resources Commission (WRC) and the Division of Marine Fisheries (DMF) have drawn a line between where they manage inland fisheries and estuarine fisheries. Would insight into how those lines were determined illuminate this discussion?

*Comment:* It is true that we are not withdrawing brackish water for supply, but we may later. More to the point, significant alteration of the water in the upstream segment in a different class could violate the base line of a coastal stream; therefore, it behooves us to consider the base line of the coastal stream.

*Comment:* The inputs from the upper segments are going to help define the salinity at the lower reaches, at least partially.

*Comment:* At least in the basins I am aware of, there is no correlation between the boundary between tidal or non-tidal or fresh or not fresh. The WRC/DMF line was agreed upon fairly arbitrarily.

*Question:* Are there alternatives to the stream classification approach that we have not been presented with that we should be considering?

*Response:* One of the documents we have yet to refer to is about the Susquehanna River (Nature Conservancy, 2010) (available at http://www.ncwater.org/sab >documents > March 15, 2011) where they used a combination approach: (1) hydrologic classification, and (2) they pulled in other sampling data of organism density. We could also go with a strictly biological approach. One reason we went with the hydrologic classification approach is because we have the river basin models, but we recognize that hydrology is not the only thing that determines ecological flows.

*Response:* There are lots of approaches in the literature that are similar to ours and produce congruent results, so I think we have a good working hypothesis, which we can refine as we gain understanding of the relationship between the biology and the hydrology.

*Question:* Are we going to develop more data for smaller streams, which cannot be gaged?

*Response:* This is a weak link. We do not have much data for small streams (headwaters), but fortunately, not much water is taken for water supply purposes at these points.

*Comment:* We seem to have little biological information on both the smaller and the larger streams, the two extremes of flows. How much overlap do we have between the physical hydrologic modeling and the ecological assessment that has been done in NC streams? Do we have the biological data primarily for the smaller streams or for the larger streams, or are we basically working from the middle outward?

*Response:* This raises a number of issues. We have yet to define "biological information". Typically that term refers to fish, as it is in some of the articles distributed to us. In terms of DWQ data we do not have much fish community structure information. The information we do have is taken from mid-size streams, not large rivers or very small streams. In terms of macroinvertebrate information, which we happen to have a great deal of, most of that comes from mid-size streams. We have some assessments of streams with drainage areas under three square miles, but our ability to categorize the quality of that biological classification is difficult, and our window of assessment opportunity is just a few months each year. I think most of our water quality information in terms of benthic macroinvertebrates is going to be in relatively small streams, but not very small streams. In terms of our fish community information, that database we have is very small and not useful to this group.

*Comment:* Regarding these small streams, in the Susquehanna report, even without a lot of data, they treated those as different because taking out just a small amount of water from a small stream can be a problem especially at low flows. Even though they were not data driven so much, it was expert opinion to treat these watersheds differently. I come back to "What are we trying to do?" ELOHA suggests that we break things down by class, but do we do this purely on biologic or hydrologic data? There is no right answer, and our understanding will develop over time.

*Comment:* Research Triangle Institute has developed a model predicting flow based on climate, including for very small streams. Probably the day will come when we will be modeling well above the top gages, but right now we are starting where we are.

*Comment:* DWR wants the EFSAB's approval of the classification approach. No one seems opposed to using this as a starting point, but we may change our mind as we move forward.

*Response:* Can we consider putting boundaries on this 7-class classification approach within the realm of the data we have at hand, and leave it open that we use an entirely different approach for those streams that fall outside of that boundary? It might be based on watershed area or climatic conditions or how much biological data we have. Perhaps we take a staged approach, acknowledging that this modeling approach seems to fit within these boundaries.

*Response:* I like the idea of putting an upstream boundary beyond which we don't pretend our expertise can extend until we have new supplementary models. I think it is rational to treat the upstream boundary of our work as the point beyond which we do not have any measure of flow except unregulated inflows.

*Comment:* To clarify, it is not that we don't have flow data for those upstream reaches. It is that we have not considered all of the data we do have in this classification approach. If you are saying that we need to consider the data that are out there, then that could be the supplemental part you are talking about.

*Comment:* If we have data for headwater reaches, perhaps we should get that data to Environmental Flow Specialists (EFS) and ask them to see what they can do with it.

*Comment:* Coweeta data might be a possibility. Stormwater data seems to me to be somewhat artificially generated.

*Response:* Maybe we do have some watershed information we could include here.

*Comment:* We only used USGS data. If a stream was not in the USGS data, it was not included. There may have been one gage from the Coweeta experimental station. There may be USGS data from a specific storm water study, but that would be from highly altered areas, which we are trying to avoid in the classification analysis. I don't think there is much additional data available.

*Question:* If we have Forest Service or University study data available, is there any reason not to look at it, and see if it is classifiable?

*Response:* I don't think there is a reason not to; I just don't think there is a whole lot of it.

*Response:* Forest Service (both NC and US) and others have some studies on small streams. I think that if you mine that data, you can find some.

*Response:* If anybody is aware of data that can meet the 15-20 year criteria and can send it to Jim Mead or Sam Pearsall to send to EFS, you need to send us the data or tell us explicitly how to get it.

*Response:* These were very short-term headwater studies.

*Comment:* All wastewater treatment plants with NPDES permits do stream sampling (upstream and multiple downstream sites) for water quality parameters such as dissolved oxygen, pH and temperature, which is sent to DWQ.

*Question:* We have classifications for small flashy streams and small seasonal streams. Are we talking about even smaller streams?

*Response:* For these really small headwater streams, the question is whether there is much data that went into the classification, and really, the answer is no. And then the question is whether we are going to be able to simulate that data and come up with classifications for them, and there is a limit to how far upstream the simulation can go. At some point there is just aggregated data beyond some upstream limit. Again, the good news is that there are usually not a lot of withdrawals beyond that limit, which is part of why the models don't break things down more finely.

*Comment:* The RTI model (WATERFALL) broke the Neuse Basin into about 9000 catchments to come up with their hydrologic simulation. It was very driven by land cover. It might be useful as a front loader for OASIS to give a handle on these very small streams and on land use and climate change and how those might affect hydrology as we move into the future. RTI has an alpha version but just for one basin. It might be useful for the future.

*Comment:* Looking at the appendix to the report on the NC classification system, they show the drainage areas, and they go all the way down to less than two square miles, which is pretty small. The question then becomes whether those are all in one classification type or maybe two. That brings to mind, "What are the upper limits of certain classification types?" We have a lot of information with which we can try to answer that question.

*Comment:* In terms of water withdrawals, the greatest influence in terms of losses of water in headwaters, tend to be farm ponds. There are many of those, and they account for a great many losses in those headwaters, especially in the piedmont. I think it can be important to note that there can be losses due to regulation, mostly from evaporation and irrigation. Each withdrawal is not singly so large, but collectively can be huge.

*Question:* Does DWR have its own boundary on the size or discharge of a stream that you are interested in?

*Response:* For planning purposes there is a node everywhere there is a need for understanding either known or anticipated flow changes. That has set a de facto upstream limit, although as pointed out, some types of flow alterations are not the type we typically deal with. We do not have a lower limit; it is driven by potential use. To loop back around to an earlier comment, what we have is a pretty good approach, but for the headwaters and for the downstream, coastal reaches there are some questions. Perhaps we haven't accounted for everything we need to in those areas. Maybe what we need to do then, while not forgetting about those, is rather to put placeholders there. As we move forward on determining ecological flows, we may realize other ecological characteristics we are not accounting for, and we will have to revisit classification at that time anyway.

*Comment:* Regarding the larger streams in the coastal plain, salinity can certainly affect ecology but regulation of the middle reach of the stream can influence the movement of salinity upstream, which can in turn affect the classification of the streams and of the wetlands around the sounds, so it gets complex . It is very important regarding the ecology of those lower reaches of the rivers, even many miles upstream if you consider how that salinity can wedge upstream, and the flora and fauna can be significantly affected especially as those large rivers are regulated.

*Comment:* It appears that the EFSAB is at a point of consensus.

*Proposal*: We use the existing classification strategy and its preliminary results as the working hypothesis for going forward, that we seriously consider splitting the coastal segments into those that are tidally influenced and those that are not, and that we look for opportunities to extend further upstream.

Upon clarification, the proposal was:

- to divide the coastal rivers into two classifications, based on tidal influence, and
- to acknowledge the EFSAB can't currently address far upper reaches, and
- to acknowledge the EFSAB would like to address the far upper reaches.

*Comment*: There are models out there that might help with that challenge at some point, and if there are good data available of adequate duration, the EFSAB would be glad to look at it now.

*Response:* I think the proposal is good. As I understand it, we don't actually have gage information in the tidal areas, so how would that work? Do we have to have the hydrologic information or can we discuss the biological/ecological aspects of classification without that data.

*Response:* What we would do is have a classification without gages. Since we are talking about establishing ecological baseline for each class, this class would be challenging, but we don't want to lump them together knowing that they are distinct.

*Comment:* The Division of Marine Fisheries has at least 30 years of physical data, at least on salinity.

*Question:* DWQ does too; we have markers for how far up stream salinity is measured. That could be very useful data for dividing the class; then deciding how to characterize the ecological integrity or baseline in that class is a different challenge.

*Comment:* There may be some information coming down the pike that we can draw on from the studies being done in Greenville on the Tar River where they are trying to evaluate the effects on the downstream ecology of removing water from the Tar River. If we split coastal streams into saline and not saline, in a year or two we may have information about how changes in flow affect downstream ecosystems, even below that salinity line.

*Comment:* Additional resources for information might be the DENR Albemarle/Pamlico program, NOAA's studies of ecological impacts of seawater rise, literature search and making inquiries.

*Comment:* I could support the proposal but we should remind ourselves not to take modeling exercises beyond their built-in design conditions. This classification system was not set up and established with tidal waters in mind nor swamp waters in mind. There may be a number of other exceptions to the seven-classification system that may crop up. I would like to move forward and agree that we have a good place to start and there are many other opportunities to divide and explore other exceptions that don't fit the purpose and the database with which these started.

*Comment:* At a whole different scale, we have LIDAR.

*Comment from Webinar attendee:* I am working on the Tar River study and can send information offline.

*Comment:* Domtar is measuring flows and salinity on the Roanoke.

*Comment:* I'm not sure they are collecting flow.

*Comment:* Coweeta can provide data from 75 years for a small headwaters stream.

*Comment:* We don't have enough data to divide by tidal influence; perhaps we should move forward only extending down to the limit of where we reach tidal influence.

*Comment:* We are suggesting that we divide the coastal classification into two classes. We don't have enough information; there might be 15 classes that are appropriate. All we do know is that the current model should perhaps only extend to the boundary where these streams are tidally influenced because the current model does not include factors like tidal influence, salinity wedge, etc.

*Comment:* Perhaps what we are saying is that we understand and are ok with the modeling limits, but let's not hold up the process by trying to figure out those other pieces.

*Comment:* Let's start with the hydrologic model and start adding in the ecological, with the understanding that we may add classifications. I think we are agreeing that this is a starting point,and that we are going to move on from here.

*Comment:* There is a 30-40 mile fuzzy zone between where tide influences (further downstream) and where the salinity has an impact on the river (further upstream).

*Question:* What were the downstream limits of the modeling?

*Response:* The downstream boundary is at the point of tidal influence.

***Proposal:* Move forward using the existing classification system strategy as a starting point, with the opportunity to add or modify additional classifications as we gain data.**

*The EFSAB agreed to this proposal.*

## VI. Instream Flow Incremental Methodology (IFIM) Presentation

Jim Mead introduced Ty Ziegler, P.E. from HDR/DTA who provided a presentation on **Instream Flow Incremental Methodology to the Ecological Flows Science Advisory Board at the March 15 meeting.** The presentation introduced a methodology to quantify how flow can change and affect aquatic habitat. Ty took questions of clarification throughout the presentation, followed with a question and response session. Ty began his presentation by describing instream flow and Instream Flow Incremental Methodology (IFIM). He explained that IFIM is a way to relate: *changes in river flow to changes in the amount of aquatic habitat on an incremental basis,* by looking at very fine increases or decreases in flow and the resulting effect on aquatic habitat.

Ty mentioned that many of the EFSAB members are familiar with USGS gage data, with the relationship between River Stage (ft) and Discharge (cubic ft/sec). He explained that the Stage vs. Discharge curve relates changes in the flow to changes in stage; usually as the amount of discharge increases, the river stage increases. With IFIM, according to Ty, the objective is to come up with the relationship between Habitat and Discharge, with discharge along the x-axis and weighted usable area (habitat in a unit of measure) along the y-axis. The difference in the relationships is that with Stage vs. Discharge, as discharge increases, the river stage increases; in Habitat vs. Discharge, as discharge increases, the habitat data can be all over the place depending on the type of aquatic species and given different habitat needs of different life stages of the species. For IFIM studies, it is a milestone step to come up with this relationship.

What's important for defining aquatic habitat for IFIM? While many factors are important in defining aquatic habitat, including food availability, predators, water quality, and water temperature, four physical parameters are considered in IFIM: depth, velocity, substrate and cover (hiding spots).

These parameters will affect different species differently and different life stages of a single species differently. As an example, habitat suitability criteria as a function of depth are presented for Channel Catfish at the three life stages: adult, juvenile and spawning, with the curves varying significantly for the three life stages. For example, adult Channel catfish prefer depths from just under 2 ft. to 5 ft., while the juvenile life stage does well at depths of 1 ft. to just over 4 ft. Ty presented examples of habitat suitability criteria for Channel Catfish using habitat suitability criteria of velocity, substrate and cover (the building blocks of the IFIM process). Slide 9 considers the habitat suitability of Channel Catfish based on 18 different categories of substrate and covers (examples of substrate include sand, gravel, boulder, bedrock, or cobble; examples of cover include roots wads, overhanging vegetation, instream vegetation, or undercut banks).

So how do we do this? Ty presented ten (10) steps of the IFIM process.

1. Field Reconnaissance & Habitat Mapping
2. Study Design
3. Habitat Weighting
4. Transect Selection & Setup
5. Field (Flow) Measurements
6. PHABSIM Modeling
7. Time Series Analysis
8. Habitat Results
9. Habitat Based Flow Determination
10. Study Report

### 1. Field Reconnaissance & Habitat Mapping

IFIM begins with field reconnaissance. For a project that covers miles, an aerial view assists in providing a large view of the different features of the river and its habitat. For smaller projects, on-the-ground surveys yield important information through habitat mapping. Habitat mapping helps ascertain the width and depth of the river, the type of habitat present, and species of importance to yield baseline habitat mapping results. This mapping can then be used to break the river into different segments, which is important because a shallow wide-glide sandy bottom provides different habitat from a narrow shallow pool.

Populations other than fish that can be studied using IFIM include mussels, frogs, and plants, for example. As long as habitat suitability criteria of depth, velocity, substrate and cover are available for the species to be studied, an instream-flow model can be developed for that particular species.

2. **Study Design**

Once the field reconnaissance & habitat mapping are completed, the study team reconvenes to finalize the study design. A lot of different techniques can be used for IFIM studies. This includes one dimensional models, two dimensional models, or best professional judgment, or combination thereof in different reaches of the river system.

3. **Habitat Weighting**

One can break up the reconnaissance data by frequency of riffles, runs, glides/shallow pools, and deep pools and weight these areas. Even a habitat type with limited frequency may need to be included depending on the purpose of the study. A habitat type with a small percentage should not be excluded simply because the percentage is small since the habitat may be important for a particular species. An example of habitat weighting:

| **Habitat Type** | **Number of Occurrences** | **Total Length (ft)** | **Percent(%)** |
|---|---|---|---|
| Riffle | 4 | 431 | 11 |
| Run | 3 | 591 | 16 |
| Glide / Shallow Pool | 4 | 1,041 | 28 |
| Deep Pool | 3 | 1,701 | 45 |
| **Total** | **14** | **3,764** | **100** |

4. **Transect Selection & Setup- Example Elk River**

With the study team, a number of transects are picked for data collection. In the Elk River example, Ty's team picked 8 transects (no mention was made of the criteria to select transects).

5. **Field (Flow) Measurements**

Once the transects are selected, the field measurements begin. Ty discussed slide 24, a one-dimensional study of instream flow method (PHABSIM), where at each cross section (at each transect), a cross-sectional profile is developed. Survey protocols and controls are established on either side to ensure testing is conducted at the exact same location every time under different flow conditions; the researcher will collect the same type of data each time in the same location. The data to be collected is substrate/cover, velocity, and depth. According to Ty, testing is conducted incrementally across the transect. Each cell provides information about the flow (velocity x area =flow). Total flow is determined for the transect by adding up all the cells.

Examples of different methods to collect field data were discussed based on the terrain. For inaccessible areas, researchers can wade across the river to collect depth and velocity information (manual method). For areas that are more accessible, wider or deeper, a researcher can use a different collection technique such as ADCP (Acoustic Doppler Current Profiler) mounted on a cataraft with a GPS unit to collect velocity and depth. The ADCP can collect finer details incrementally such as velocity measurements at various spots across the transect in a given depth measurement (ADCP Velocity Magnitude Profile). In some channels both the manual wading method and the ADCP method may be required to collect data. In general the two methods for gathering data are the manual wading method and the ADCP type method. Whichever method is used, it is important to maintain good survey control to know exactly the distance and elevation measurements, what the water surface elevation is, thus being able to calculate accurate depths for each cell, to measure discharge appropriately.

IFIM studies can require a lot of gear and people and thus are not always appropriate given limited time and resources. There are cases where instream flow studies can be relatively low intensity efforts such as on a smaller creek. For example, when stringing a tape measure from one side to the other, one person using a velocity meter can, in 30 minutes, move across and collect the data at that flow.

The reason to collect data under various flow conditions is to have calibration data. Calibration data help develop a relationship on the spectrum between three data sets: low, medium, and high. The relationship between the data allows the researcher to extrapolate what depths and velocity would be at a higher flow or lower flow than what was actually measured. Sometimes there is only one field season or one week during a control release from which to gather measurements. To take full advantage of the model, the researcher can use calibration data to simulate other flows of interest.

## 6. PHABSIM Modeling – what is PHABSIM? Physical HABitat SIMulation Model

A model first developed by the US Fish & Wildlife Service, PHABSIM is fairly well known and widely used with its limitations acknowledged. Ty believes PHABSIM is a good tool to help determine what kinds of flows provide what kinds of habitat. Conceptually the model works by taking a section of river and dividing it into cells (or patterns) of various combinations of substrate/cover, depth, and velocity. The model figures out the physical features that are located in the river.

The goal is to relate this information to a species of interest. Ty used an adult Channel Catfish example introduced earlier (Habitat Suitability Criteria – Depth), specifically the adult catfish's preference for depths of 3 plus ft. Using the PHABSIM model, optimal habitat areas (where the adult catfish prefers the channel the most) that are greater than 3 ft. deep with low velocity are identified. In this example, the optimal area totals 432 sq. feet. The optimal area is not the only area that the adult catfish can be found; there is also a usable area of 876 sq. ft. where adult catfish can be found and an unsuitable area of 759 sq. ft. (unsuitable meaning the area is too shallow, the velocity is too high or it's the wrong substrate or cover).

The model is run numerous times using different flows to determine how much habitat is available for the adult catfish, calculating the weighted usable area beginning with 100 cfs and so on up to 23,000cfs. This process creates a flow to habitat conversion. Note that the habitat area begins to decrease at flows over 3850 cfs (this flow to habitat relationship creates a curve, which is very different from a stage to discharge relationship).

Ty stated that sometimes folks want to manage for the 3500 cfs peak habitat and stop here. But Ty does not recommend using the flow to habitat conversion data in this manner. The weighted usable area only provides the *magnitude* of available aquatic habitat but not the *frequency* at which it occurs.

### 7. Time Series Analysis

For frequency at which the habitat occurs, flow data needs to be introduced. From the USGS gage data, a time series analysis can provide the flow data frequency information based on a daily average flow. For every daily average flow value available, there is now a daily average habitat value.

With respect to timing, the model needs to be informed about the presence of life stages for the species of interest during different parts of the year. Some species are present year-round while others are not. If the Carolina Redhorse spawns April and May, then the model will only provide data during those parts of the year. For example, slide 48 shows a comparison of spawning and early life stages of the Carolina Redhorse, American Shad, Striped Bass, Cape Fear Shiner, Bluehead Chub, and Channel Catfish.

### 8. Habitat Results

Ty presented a habitat duration curve (slide 50), labeled:

Exceedance Area Under the Curve (AUC) 1% to 100%
Period of Record 1930-2009
Creek X Node 1 – Species Example A
August – All Water Year Types – Alternate Min Flow = 5.0

X-axis is percentage of time equaled or exceeded; Y -axis is an index of total reach habitat (or sq. ft).

In this example, three different flow scenarios are presented. The red line is the unimpaired (unregulated) flow; the green line is the alternative unregulated flow; and the blue line is regulated flow.

Say for instance, that whatever is regulating the flow is removed (in this case a dam is removed). The researcher is then able to simulate the period of record hydrology, which results in the red line. What the red line says (since this is a percent exceedance curve) is that about 50% of the time for a particular species in the month of August there is more than 116,000 sq. ft. of habitat available and about 50% of the time there is less than 116,000 sq. ft. (Ty referenced the index of total reach habitat on the Y-axis as sq. ft.)

In the next example, the dam is in place and the researcher simulates the same hydrologic period of record, which results in the blue line or the regulated flow. Because of the regulation, there is about half of the habitat available or about 55,000 sq. ft. at the 50% percentile in the regulated case. The tool can now be used to add flow to the regulated flow scenario to ascertain how additional flow will affect availability of habitat. By adding 5.0 cfs more in August than the blue line, this increases the availability of habitat to about 93,000 sq. ft. at the 50 percentile. And you can also see that there are flows in August with the alternative regulated flow, whereas a drought may have existed for the unregulated and regulated flows, which left little habitat. Again, by adding 5 more cfs than the blue line, the increase in flow also increases the habitat area fairly significantly during the drought conditions at the 95 to100% percentile for both the regulated and unimpaired flow scenarios.

In the next examples (slide 51-53), the researcher wants to explore the same species in its life stage, during the same period of record but for all 12 months. The slide titled: Interactive Habitat Results *Option 1: Existing Conditions* presents the red line as the unimpaired (unregulated) flow; the blue line as the regulated flow; and the green line as the alternative unregulated flow. In option 1, the green and blue lines are the same for each month as additional cfs are not added. For the month of January, under existing conditions, the unregulated flow provides less habitat than the regulated or alternative unregulated flow scenarios, and provides a little more habitat in the months of Feb and March, and then significantly more habitat is provided in April through Dec by the unregulated scenario.

Next examples are the Interactive Habitat Results Option 2: 80% Unimpaired and the Interactive Habitat Results Option 3: Match Unimpaired. Each example looks at the same species in its life stage, during the same period of record but for all 12 months. Option 2 considers the addition of 3 to 4 cfs from May to Dec to increase the alternative unregulated flow; Option 3 considers the addition of 4, 5, 6, and 10 cfs to various months beginning with Feb.

## 9. Habitat Based Flow Determination

Slide 54 shows a comparison of the 12 months based on the options. The purpose of running various options is to provide the study team with different proposals to determine appropriate scenarios for the purpose of the study. There are limitations, tradeoffs, and advantages. All have positive effects on some things and negative effects on other things. These options will help guide decision-making. In this case, the researcher can incrementally add flow until the stated habitat objectives are achieved.

| Month | Option 1 Existing | Option 2 80% Unimpaired | Option 3 Match Unimpaired |
|---|---|---|---|
| Jan | 0 | 0 | 0 |
| Feb | 0 | 0 | 5 |
| Mar | 0 | 0 | 6 |
| Apr | 0 | 0 | 10 |
| May | 0 | 4 | 10 |
| Jun | 0 | 4 | 6 |
| Jul | 0 | 3 | 5 |
| Aug | 0 | 3 | 4 |
| Sep | 0 | 3 | 4 |
| Oct | 0 | 3 | 5 |
| Nov | 0 | 3 | 6 |
| Dec | 0 | 3 | 6 |

Is this the answer? No, its only part of the answer. There are other drivers in the system including the list below. Decision makers need to take these into consideration with other studies.

Water Supply
Water Quality
Recreation (eg. paddling & angling)
Aesthetics
Lake Levels
Economics

**10. Study Report**

You need good documentation of the study results, especially to have a good solid basis from which to build future studies.

Nancy Sharpless, facilitator, then solicited the EFSAB's comments, recommendations, and questions regarding the IFIM presentation:

**IFIM Comments, Questions and Response Session:**

1. Comment: Please go back to slides on Options with the red, blue, and green lines that examined the regulated and unregulated proposals. The examples Ty presented are about evaluating regulated and unregulated systems, having some existing conditions, and trying to improve them. Another way to come at this would be if you do not have any modifications to the hydrology but just existing conditions (the red bars), then what conditions will you place on the proposal, so that the green and blue bars do not drop too far below the red bar. How far is too far and what does it all mean, becomes the subject of much discussion and negotiation. One reason DENR is interested in looking at this [approach] is that we do have a smattering of these

studies around the state. Our thinking is that this might provide us with useful information to look at the red bars, and then using the Oasis type models, running all different proposed flows, to help determine where the green and blue bars go if one does A-Z? This is one piece of information to help inform our discussions for ecological flows. These studies are one way to make the link between aquatic habitat and flows. This kind of information will be available in May for the Eno field trip.

2. **Question:** My question pertains to 20 years from now as you come back to your original study. Assuming that bank flows will change the instream morphology, when you are modeling on a big scale for planning purposes and over a larger time scale presumably as well, how do you translate your previous scale to a bigger scale knowing your river morphology is going to change? Do you just assume that the percentages of riffles, runs, and pools are essentially maintained even though they may shift through the reach?

**Ty's response:** Your question is already on the way to a response. You got your baseline habitat mapping. It is important to ensure that when you collect the data the channel is stable and the measurements occur in the same exact spot, for each of the flow measurements. We know that when we leave a flood event may come which could affect the channel. So you may want to repeat the habitat mapping effort. If the riffles and runs are in a different location, they may or may not maintain the same percent of weighting. The information on weighting used in the model is a conceptual division of the cross sections from upstream to downstream in different cells. The model does not care in what order the physical features occur. Even if the percentages change you may not need to recollect the data.; you tell the model that the stream is 45% deep pool and 25% shallow glide –so that if these percentages change, you may not have to recollect the data based on what the study team decides; you may simply rerun the model with different weights such that now its only 30% deep pool and the other 15% got divided with other habitat. This would be my first approach.

**Another member contributes to the response:** It is a model; we are not using it to give us exact answers. We are using it as a tool to help us analyze scenarios. There are a lot of other assumptions as to how we are representing habitat and what those really mean to the critters out there. So from my perspective, we use it as a tool to help guide decisions. Over time, things might shift around but it's still representing generally what's going on out there.

**Comment on initial question:** [My initial question drives at the instability that I predict will be there]. I think from an instream situation, the stability for many of our Piedmont streams is being compromised. We are perhaps seeing changes in the substrate and the overall composition (riffle, run, pools), which may result in substantial difference in what we measure now to what is measured within the next 20 to 30 years. I just did not know how fundamentally that may affect our ability to assess the amount of discharge we are going to have in a given area based on our current stream gages. If you do not have stability then there is underlying mismatch. And I know we probably won't have stability in a lot of these streams.

3. **Question:** These models seem to be good at predicting physical habitat change and availability. Do you have enough experience with these types of models to understand the dynamics of

interaction between species? Of what really happens when change in habitat might favor one species under one set of conditions but also might favor the predator of that species? So in the real world, when you make these changes, do you have enough experience to say that the species interaction doesn't overcome or in some way compensate for some of these changes in your habitat model output?

**Ty's response:** There are two ways to answer this. You use the model information as a guide for which kind of habitat is increasing and which is decreasing. But then that's where your best professional judgment comes into play to say that now you are creating a habitat for a species you do not want to manage for; your expertise tells this, not the model.

Second, there is alot of research in that field, but the research I'm aware of is on smaller size rivers, creeks and watersheds. Once you start entering information that is outside the physical parameters such as biological requirements then the data requirements increase; the complexity of the study increases and the uncertainty of the study results increase.

It's a good question. At the university level there are good programs looking at this in the Mid-Atlantic states. Most clients I have shy away from these studies because of the uncertainty in how to deal with the results. They are on a one year FERC timeline that will not allow them the time to collect and assess three to four years of data. Progress is being made here but it's not widespread scale application given the constraints. Most people I know use best professional judgment.

With water quality, the same thing; you might provide the most awesome physical habitat out there but if your water quality is not conducive, you will not see a population increase. Habitat does not equal fish, more plants, or more yellow-legged frogs. It is an indicator that the habitat is present. But if the water quality or some critical quality is not there or something else, you will not see a population increase.

4. **Question:** The other part of this is that the input seems to be based on species occurrence. The input data is a species' habitat preference. Most of that is generally assessed by sampling, determining how many are there today. And it may not reflect a metabolic optimum for that species. Just because that's where you find the most of that species, doesn't mean it's the best set of conditions for the fish. Again, I'm not sure how much research has been done along these lines.

**Ty's response:** With the habitat suitability curves, there is kind of a hierarchy to them. There are tier one, two, and three curves. For some of the curves, there was relatively little field study done on them, meaning that the experts got together and decided based on what they know; this was better than taking no shot at it all. For other curves, there is quite a bit of research behind them. For some species there are curves that are particular to different regions of the country. So it is important to understand the data you are putting in. The model does not know the source. It is an important aspect of the studies. **Don Orth at Virginia Tech** has done a lot of work studying habitat suitability criteria.

5. **Question:** I'm rephrasing Jeff's question, but in terms of validation studies, how many validation studies are there where they have gone in, set this up, and tested the stream flow, the effects of the stream flow – 100s? tens? 2?.

**Ty's response:** I'd say more than 2 but do not know about 100s. I'd say the vast majority of researchers do not go back and check the models developed. They may develop a model that included 20cfs as the minimum floor and then study it consistently for twenty years while factoring in natural variability between wet and dry years. These tools are used worldwide. France has conducted some studies where they have taken ½ dozen or a dozen streams where this type of technique was used to establish minimum flows, and they went back to see if the model resulted in what they thought it would; in some cases it did and in some cases, it did not.

**Other members are asked if they would like to add anything on that:**

- No, you have portrayed it where it's at. There is some research out there, but seldom is anyone putting money into the long-term monitoring.
- Some of the best examples in NC where there have been improvements, hopefully, in flow and aquatic habitat have just been recently instituted in hydropower relicensing, or we're still waiting for the license to be issued and for the improvements to take place. So there hasn't really been time for the hoped-for improvement to take place or to see how much improvement we are getting for a given change. Maybe in 5 to 10 years we will have more data specific to North Carolina about the kinds of improvements we are getting.
- The ongoing McManamay study references the Tapoco project on the Cheoah in NC. We introduce flows, had some hypothesize species, and community benefits. He has been testing those and the work is still ongoing. He had to look to a broader region to explain some of the differences in the community fish response (the interactions, the predation, the competition, as well as all of the seasonal fluctuations, something you cannot test in the initial year when you do physical modeling).

6. **Question:** How does temperature factor into these models?

**Ty's response:** Temperature is an important factor. I lumped temperature in with water quality and so this particular model does not account for temperature. You would have to look at the result and say we're going to provide optimum habitat in this reach this time of year. But you would also need some supplemental data on what kind of temperature would result so that you do not provide habitat into a situation where the temperature is not conducive, so you're not accomplishing your objective. Temperature often is not included as part of the model output. Usually you are collecting supplemental data to understand the thermal regime of the river you are working on.

**Another member contributes:** There are some companion models that look strictly at temperature, one's two dimensional and one a network of extreme temperatures to go along with these flows; so those get pretty complex as well.

**Ty continues:** Fortunately temperature modeling is fairly well understood as temperature is a physical process. The modeling community has developed numerous riverine and reservoir type models to look at temperature. Alot of times what we'll do is have a study where one model yields flow regimes to provide our habitat goal and another model looks at how we will deliver that flow. Particularly where will we get the water if it's coming from a reservoir; if that reservoir stratifies, will it come off the surface? come off the bottom? or have a selective withdrawal? It is correct to say that you need a companion model or companion data to go with these instream flow tools.

7. **Question:** How do you balance the needs of various species to provide recommend flows?

**Ty's response:** Great question, that's why these studies are usually done in a collaborative fashion. You need to understand what your management objectives are. If your driver is to maintain a native community of shiner, minnow, and darter species, and they prefer a certain flow regime, and that's the flow regime you go with, that flow regime is going to be the determinant of something else. So you need to know what that determinant is and is it a balancing act. One technique, regardless of your management objective, in developing flow recommendations is to look at what species are most sensitive to changes in flow. If you have 20 different species life stages, and five are most responsive to changes in flow, maybe for the 15 others it does not matter so much what the flow is as long as it is a little bit more or a little bit less and in the meantime you focus on a set of driver species. It is a difficult question.

8. **Question:** How do you use the IFIM process to address/describe the variability of flow?

**Ty's response:** Well you are using that variability in flows during a time series analysis, say for the month of August, you are looking at all of the days of August for 80 years of record. You are looking at alot of "Augusts", some that are wet, some that are dry, and you are factoring that into the results. That is why you see results of 5% when there is no habitat available because maybe the channel dries, perhaps due to a drought. You are using that variability to test different flows. You can set the minimum flow of 20 cfs, but recognize that the system once every 10 years experiences a flow of a 1000 cfs. If the model has that capability to go up to 1000 cfs, then you can look to see what kind of habitat is present at that higher flow. Again, you still need to use your best professional judgment as to how significant the information is based on the overall scope of your project.

9. **Question:** Can you use a tool like this to develop operating guidelines for dam or hydro releases?

**Ty's response:** Absolutely. The tools generate results on a monthly basis so that you can look at things like spawning season, or typically lower flows in summer and fall months vs. higher flows in winter and spring months. It will give you the ability to look at establishing minimum flows, typically on a monthly basis, but it can provide weekly information as well. Most operators will prefer a monthly view to set general parameters for operations, rather than having to tweak operations on a daily basis.

**Another member contributes**: In terms of how simple, complex, or variable you want to make your test of a flow recommendation, if you refer back to the plot (slide 52 as an example), whatever you pick to generate those green or blue bars can be as simple as one flow for the year or as variable and complex as you want it to be. That flow is what generates the blue or green bar which you are then comparing to the red bar. If you want to assess how much you've changed the red bar you can do that, or if it's a variable, you can assess that.

One thing that starts to get at and help us evaluate species with different preferences – when some do not like fast flows while others prefer fast flows – is the analysis that goes into the chart we are looking at (slide 52). The unregulated (the red bar) is based on how much habitat was there under the unregulated and unimpaired flow regime. If it's a guild or a species that likes really fast water but it's a low flow month with slow water, well that red bar is not going to be very high for that species. So we're looking at percentage comparisons of a proposed project flow to an unimpaired flow. On the other hand, if there are conditions naturally that favor that species, well the red bar is going to be high. You can look at these kinds of things and say that we are hurting one species at the expense of other species. However, if Mother Nature was not providing a lot of habitat for one of those two species, that information may help guide a recommendation in flow. Or we might say, we are going to manage the system artificially because there are other management priorities for that system. But what you use to generate the red bars up there can shed some light on that question.

10. **Comment/Question:** Where I think these tools are being used most often is when there is a dam and you're getting more releases because dam operators can increase your cfs when you ask them to do so. What I'm unclear about is how these tools work on the flip side with withdrawals, when you take flows away at a given time, and you do not have the ability to increase flows to increase habitat availability. In the planning system, where do you see the control coming in with withdrawals?

**Jim's Response:** We have used a similar type of analysis for what we call "run of river withdrawals" where there is no water storage available to give you more water. It is a different way of generating a flow record: it is flow minus x that generates the green or blue line (or flow minus y, flow minus z, and so on to get a whole series of blue and green lines to compare to the red lines). Based on this information, this planning system should cap withdrawals at a certain amount or determine if their proposed increase is hammering the stream too hard or maybe it's ok.

The second part of your question is tricky because some types of withdrawals do not have the flexibility to take in this much in some months and this much in other months. Most water systems cannot operate in this way unless they have alternate sources (or interconnections or off stream storage). Although this is project specific, some systems may need a way of getting additional water for at least three months out of the year while for the remaining 9 months, the stream is able to meet their needs. If the water were removed for those 3 months, it would cause an unacceptable change. Hence you'll need to look to an alternate source for those 3 months. So you can use this analysis for run of river withdrawals as well as big reservoirs.

**Ty's response:** Here's what I would do to address your question from a modeling perspective. You could have two different regulated flow regimes: one regulated flow regime that represents the current condition and another regulated flow regime where a withdrawer is removing a certain amount of water during a certain time of year. All this is, is a comparison tool of different hydrology sets that have habitat incorporated into them-–so you can look at Regulated 1 and Regulated 2. The difference between them is some sort of pumping scheme. So someone could develop several different regulated flow regimes that are based on different future demand scenarios and you could run it using this tool. You would name the red, green, and blue bars differently, but that's how, from a modeling perspective, you could get at your question.

11. **Question:** Do you have methods for assessing uncertainty for these different components and getting at the critical issue which is really what's the probability that you're going to wind up falling below some critical level? You're really dealing with means here but perhaps what you really need to be doing is saying this is the value I need for 95% protection.

**Ty's response:** Is the question more on what is the uncertainty of the tool? Are you saying is it plus or minus 25%?

**Question continued:** That's the basis for it but what you really want to know when you implement these things is if you put this scenario into action, you've got uncertainty associated with it. So with the mean value, you've got to add 4 cfs with the uncertainty. It may be with the uncertainty that you need to add 20 cfs to be sure that you have an 80% chance that you are not going to fall below that habitat level.

**Ty's response:** For people who did not hear, it was suggested that you could use IFIM in concert with the Oasis to look at uncertainty. Basically if you looked at a sensitivity analysis on the hydrology you could run a new hydrology using the tool and look at sensitivity to changes in flow. There are several components of the model that you could do sensitivity on and one of those is the habitat suitability curves. Some of them have more data behind them than others so you could tweak the habitat criteria. Example: you could say I'm not sure that adult catfish like 2 to 5 feet depth, so let's change it to 3 to 10 feet depth. Would that change the result? You could run that through the model and say it prefers deeper than what I told it, does that mean it would increase the minimum base flow? The uncertainties are the hydrology and the habitat suitability criteria you enter; the relationship between depth, velocity, and flow are pretty well understood. You could do sensitivity analysis with the model to see if the results hold or under what conditions would you break it and have a different flow recommendation.

**Another member comments:** That's what I was thinking of, sensitivity analysis based on some uncertainties in preferences in depths and velocities.

Another thought is to set a flow threshold within a year or over a series of years, where all of a sudden you get a severe drought. Do those flow conditions still meet the habitat needs when your inflows are low, when you are in some extreme situation? There are a couple of ways to look at that. One would be wet, dry, and average year recommendations and operating criteria in setting ecological flows.

Another example is when unimpaired flows hit really low levels. You can't avoid those. Another person around this table likes to say that really interesting things happen at the tails. It may be that there are some critters out there that are not part of the modeling and they rely on a reset, maybe suppressed predators for example, so you do not totally want to eliminate those from happening.

**Ty's response:** In looking at my example on the board now (slide 50), the green line stabilizes the flow in August at 5 cfs, you're basically eliminating that event of extreme low flow (naturally it would have been lower). In some cases by trying to mimic the unimpaired you are actually not mimicking the unimpaired, you are still providing a floor amount of habitat.

12. **Question:** In the collaboration for which species we are going to include as we walk this walk, we are going to have to choose which ecological factors go into the model. When I see this type of modeling, it makes me very aware that we will need to come to some conclusions about which ecological factors we are going to ultimately include.

**Jim's response:** That is an excellent point. Because the results you have, you will have a plot like this or a bar chart for every organism that you choose to evaluate. Our all time high was 32 sets of species/lifestages. We try to focus on organisms most sensitive to change. Early on what ones you pick is important. What you try to do is pick the whole suite that is present or that you expect to be present for that particular type of stream. The most changeable areas tend to be ones that prefer shallow slow habitats or shallow fast habitats when you change flows. We tend to get away from just looking at one individual species and broaden it to consider the guilds, focusing on a group of species so you are not looking at one particular type. So yes, it is a good thing to keep in mind.

13. **Question:** Have you tried modeling, thinking of migratory species for example, have you tried using this model type approach to evaluate the effect of variability on species, not just a set habitat of a fixed amount plus or minus but the variations in habitat itself? For example, increasing flows and decreasing flows, they may stimulate some kind of response in a particular species.

**Ty's response:** I have not been involved in a study like that but it is similar to Jim's earlier response. By establishing a stable flow regime during a time of year when you went through some very significant extremes; it is something to keep in mind.

**Jim's response:** That's a really interesting point. I'm not aware of using this tool for looking at flow cues. One of our limits is what our level of knowledge is about what cues those things. But let's say that you wanted to test a hypothesis such as a two-day increase pulse of flow that tends to get them charged up and they run. One way to get at your question with this kind of tool is to remember that this information is an amalgam of lots of daily flows over many years and grouped by month. You could shorten that time step to look at: what happens during this week? How does habitat change for this species if you jump the flows up and then down? You could put it under a microscope for short-term events to see what is really going on.

**Ty's response:** Ramping rates analysis is along those lines. For example, the average flow of the day is 1000, but during part of the day its 200, another part of the day its 1500 so what's the limiting habitat – was it 200 or 1500 that really had the effect on the habitat not the average flow of 1000. So we've done ramping rate studies to look at the minimum, but like Jim said, you need to shorten your time step to analyze this information.

**Another member contributes:** The IFIM methodology was not aimed at giving these types of answers. In the overall process of coming up with recommended flow regimes, that kind of information could be layered on top as a starting point to respond to these questions.  Just like we talked about with the stream classification – it's a starting point. If cueing flow is to be part of this system, there are probably other ways to get at this information for the other kinds of ecological factors that we need to consider.

**Ty's response:** Cueing flows, stabilization flows, yes there are a lot of different things you can add on top of the baseline minimum flow that you are trying to establish.

**Another member contributes:** In some cases, most notably the Cheoah River we did institute a longer flow regime rotation to incorporate that variability especially into the high flows, not the average flows. Because by definition, half the time you are above average, half the time you are below average, and so that is really a misleading statistic (3 out of 4 people make up 75% of the population when polled). Stats can be misleading  especially with hydrology and fish and any kind of aquatic community response. It's not the average that guides most of our temperate communities here in NC, it's those extremes like droughts and floods which are what define the communities that persist in these aquatic systems. For the Cheoah River, we incorporated a 5-year high flow regime, rotating, and based on that long term natural unimpaired hydrology inflow system to get that period of density so that it did not favor one species over another.

The EFSAB, guests, and facilitation team thanked Ty for his presentation and his generous amount of time.

## VII. Review Charter

A  revised draft of the EFSAB Charter was presented by the facilitation team.

- The EFSAB's review of the previous draft had illuminated differing views on representation under "**Responsibilities of EFSAB**".  The facilitation team rewrote this section to incorporate both views, emphasizing that EFSAB members must represent their expertise in aquatic ecology and habitat as mandated by the legislation, and they can also represent their constituencies in the way they deem appropriate (which is not mandated by the legislation):

  *EFSAB members will represent their expertise in aquatic ecology and habitat.  They may also represent (1) themselves, (2) the organizations to which they belong, and/or (3) coalitions of constituent groups, and their expertise in aquatic ecology and habitat.*

This language was accepted by the EFSAB.

Two other changes were suggested for the section “**Authority of the EFSAB**”.

- In the first paragraph, the current language says that the EFSAB is charged with assisting DWR in reviewing reports and that this language may be in conflict with the language in the legislation, which mandated the EFSAB. The language from the legislation will be used to replace language in the first paragraph under Authority of the Board, in the Charter.

  The language under “**Authority of the Board**” will read:
  *The EFSAB is charged with assisting DENR in characterizing the natural ecology and identifying flow requirements, and reviewing reports or studies submitted to the DENR for consideration that are relevant to characterizing the ecology of the different river basins and identifying flow requirements for maintenance of ecological integrity.*

  This change was accepted by the EFSAB.

A m**ember suggested moving** the second par*agraph to the section “**Composition of the EFSAB**.”* This change was accepted by the EFSAB.

## VIII. Revisit “Member’s Needs” from November Meeting

*At the November 8, 2010 meeting, the EFSAB was asked to list what they needed in order to move forward and achieve the purpose of the EFSAB. The list was originally published in the November 2010 meeting summa*ry.

The updated list can be found at: www.ncsu.edu/WECO/documents/EFSABNeedsList-march31.pdf. We will review and revisit this list with the SAB.

Please review the document and attach your comments in the field provided. Are there additional needs to add to the list? Do you think we have accomplished some of your requests?

## IX. Agenda for May 17, 2011 Meeting

The next meeting of the EFSAB will be Tuesday, **May 17, 2011, from 12:30 to 4:30pm,** at Eno River State Park in order to see the transects used in the habitat models for the Eno River. DWR hopes to use the Neuse River as a pilot project for evaluating effects of different flow management approaches on aquatic habitat because they have the Neuse River Basin Hydrologic Model, and they have existing habitat models for the Eno River.

THE MAY MEETING WILL BE OUTSIDE - PLEASE DRESS APPROPRATELY (raingear, good walking shoes). Please bring your own drinking water and refreshments as needed.

Rain during or prior to the meeting could result in cancellation of the meeting if the increased stream flow renders observation unsatisfactory. PLEASE CHECK YOUR E-MAIL several days prior to the meeting when we will send out a reminder. We will be in a picnic shelter at times, so light rain should not be a problem.

**Agenda:**

- Why we are here, what are we going to do
- Review of instream flow methodology
- Demonstration of instream flow methodology at river
- Questions / comments

**Directions to May 17 meeting at Eno River State Park**

The address is: 6101 Cole Mill Road, Durham, NC 27705-9275
State Park map and directions
Eno River State Park is located in Durham and Orange counties, northwest of the city of Durham.
From Interstate 85 exit 173, take Cole Mill Road northwest away from Durham. After five miles, Cole Mill Road will end at the park's Fews Ford Access.
From Interstate 85 exit 170, take Hwy. 70 west to Pleasant Green Road. Turn right and follow Pleasant Green 2.2 miles, then turn left on Cole Mill Road. After one mile, Cole Mill Road will enter the park's Fews Ford Access.

Once at the park, the meeting location is the picnic shelter in the Few's Ford section of the park shown in the upper left on this map. Because of the location and field trip nature of this meeting, web access and conference call participation will not be possible.